

Remarks

The above Amendments and these Remarks are in reply to the Office Action mailed December 20, 2002.

I. Rejections of the Claims Under 35 U.S.C. §102

1. Rejections Over Akram

Claims 48 stands rejected under 35 U.S.C. §102(b) over Akram. According to the Figures cited by the Examiner, in particular, Figure 5, a nitride layer is depicted as a planar layer overlying a metal strip. Applicants have amended claim 48 to define with more particularity, aspects of the invention. In particular, claim 48 relates to methods for protecting device stacks from adverse effects of dopant diffusion by "forming a trench in said device stack, said trench having at least one sidewall; [and] depositing on at least one sidewall, a diffusion barrier." Thus, the structure of the Applicants' invention as claimed in claim 48 is different from that disclosed in Akram, and thus, Akram cannot anticipate Applicants' claim 48.

2. Rejections Over Kwon

Claims 1 and 20 stand rejected under 35 U.S.C. §102(e) as being anticipated by Kwon et al., U.S. Patent No. 6,333,260 ("Kwon"). Applicants respectfully traverse the rejections of claims 1 and 20 and reiterate arguments presented in the previous Response. Applicants submit that *Kwon* fails to disclose all elements of claim 1 as amended and claim 20. In particular, as described in more detail below, Kwon does not teach the structure as claimed in Applicants' amended claims, and thus, cannot anticipate Applicants' claims.

Applicants submit that the amendment to claim 1, namely to "deposit directly on said metal layer, a single diffusion barrier" is not a narrowing amendment, but rather makes explicit, what was implicit in the claim as filed ("depositing on said metal layer, a diffusion barrier").

a. The Applicants' structure is different from that of Kwon

The Examiner describes Kwon as disclosing "depositing on a metal layer 310, a layer 350 which can be of Ti or TiN having diffusion barrier characteristics...and then depositing a layer of doped dielectric material 400 or 405 on said diffusion barrier." See Office Action page 2, paragraph 2. Applicants respectfully submits that Kwon does not disclose "a diffusion barrier being comprised

of a layer of metal nitride” as described in claim 1. However, Applicants respectfully submit that the structures of Kwon and the Applicants’ embodiments are different.

First, Kwon discloses **two** layers, a first **anti-reflection layer 350** and a second, separate **interface protection layer 360**. In contrast, Applicants’ embodiments recite “depositing directly on said metal layer, a single diffusion barrier.” Applicants note that neither of the two layers on Kwon separately can act as a “diffusion barrier” to protect the underlying metal layer from diffusion of contaminants from a dielectric layer above. Significantly, the anti-reflection layer 350 is situated **only** on the top side of the metal layer. Next, the interface protection layer 360 is not “directly on” the metal layer, but rather is separated from the metal layer by anti-reflection layer 350. In contrast, Applicants’ “single diffusion barrier” layer is applied “directly on said metal layer” and is not separated from the metal layer by any other layer, for example an anti-reflective layer of Kwon. Thus, the devices disclosed and/or taught in Kwon are structurally different from those of the Applicants’ invention.

Additionally, Applicants respectfully submit that the two layers of Kwon are not sufficiently similar to each other so as to be equivalent. Kwon discloses an “an anti-reflection layer 350 [which] may be formed on the metal film pattern 310.” See Kwon column 5, lines 56-57. However, Kwon teaches away from the use of anti-reflection layer 350 as a diffusion layer by disclosing a **separate** interface protection layer 360. Applicants submit that had Kwon appreciated that the antireflection layer 350 served the same function as Applicants’ “single diffusion barrier” there would be no motive for Kwon to add the separate interface protection later 360. Thus, Applicants submit that Kwon would not have included two separate layers 350 ad 360 to carry out the same functions.

Further, Applicants respectfully submit that Ti is not a “diffusion barrier” as defined by the Applicants’ application. As stated in the Summary, “These results can be accomplished by providing a layer of **metal nitride** at the surface of the metal layer prior to the deposition thereon of a doped dielectric material.” Page 12, lines 1-3; emphasis added.

Additionally, even if one were to consider a Ti layer 350 of Kwon to be a barrier layer, such a structure teaches away from Applicants’ structure. The specification states

the interface between the aluminum and titanium can be the site of formation of titanium aluminide (TiAl₃). Ti Al₃ has a smaller unit cell

than either Ti or Al alone, and the formation of $TiAl_3$ can create stress voids in the interface, resulting in poor texture. Page 26, lines 15 - 19.

Thus, if, as the Examiner indicates, a Ti layer were on a metal layer of Kwon, which could be aluminum (column 5, line 28), such a structure would suffer from the problem that the Applicants have solved by the use of a nitride layer between the aluminum metal layer and a subsequently deposited Ti layer. Applicants respectfully submit that Kwon did not, and could not have appreciated the problems of adverse texture that the Applicants have identified and solved.

As Kwon notes, "the second dielectric layer 400...may have harmful or reactive materials such as fluorine, which may diffuse to and react with the metal film pattern 310..." See Kwon column 6, lines 4-7. Kwon discloses a solution that does not rely on the use of the anti-reflection layer 350 as a diffusion barrier: "[t]herefore, in order to protect the metal film pattern 310 from reactive material such as fluorine, an interface protection layer 360 is provided between the metal film pattern 310 and the second insulative film 400...the interface protection layer 360 may be made from aluminum oxide...silicon nitride, or silicon oxynitride." See *Id.*, lines 13-16, 20-23. Kwon fails to disclose an interface protection layer 360 "being comprised of a layer of metal nitride."

Kwon also discloses a second embodiment where "the interface protection layer 360 is formed of an aluminum oxide layer, an SiN layer or an SiON layer as in the first embodiment, on the interface between the second dielectric layer 405 and the first metal film pattern 310." See *Kwon* column 8, lines 56-59. *Kwon* fails to disclose an interface protection layer 360 between the second dielectric layer 405 and the first metal film pattern 310 "being comprised of a layer of metal nitride."

Applicants submit that because *Kwon* fails to disclose a diffusion barrier being comprised of a layer of metal nitride as disclosed in amended claim 1, *Kwon* cannot anticipate claim 1 under 35 U.S.C. §102(e). Applicants respectfully submit that amended claim 1 is patentable over *Kwon*. Dependent claims 20 and 21 depend from independent claim 1 and are therefore, it is further submitted, patentable for at least the reasons given for the patentability of claim 1. Accordingly, Applicants respectfully request that the rejection of claims 1, 20, and 21 under 35 U.S.C. §102(e) be withdrawn.

II. Rejections Under 35 U.S.C. §103(a)

1. Rejections Over Kwon

Claim 19 stands rejected under 35 U.S.C. §103(a) as being unpatentable over *Kwon*. Applicants respectfully traverse the rejection of claim 19. Applicants submit that *Kwon* fails to disclose all elements of claim 1 as amended and that claim 19 depends from claim 1.

a. *Kwon* fails to disclose a diffusion barrier being comprised of a layer of metal nitride

The Examiner describes *Kwon* as disclosing substantially the limitations of claim 19. The Examiner specifically cites the disclosure in *Kwon* of "depositing a layer of doped dielectric material...carried out at a deposition temperature in the range of about 350 to 400C." See Detail Action page 3, paragraph 4. Claim 19 discloses "a layer of doped dielectric material...carried out at a deposition temperature in the range of about 200°C to about 450°C."

In view of the remarks herein in Section I 2, Applicants respectfully submit that *Kwon* fails to disclose a structure that can be made according to Applicants' claim 1. *Kwon* teaches away from the use of metal nitride as a diffusion barrier by disclosing the use of aluminum nitride, SiN, and SiON deposited over an anti-reflective coating of TiN. Dependent claim 19 depends from claim 1; therefore, *Kwon* does not render claim 19 obvious under 35 U.S.C. §103(a). Accordingly, Applicant respectfully requests that the rejection of claim 1 under 35 U.S.C. §103(a) be withdrawn.

2. Rejections Over Liu in view of Lu

Claims 1, 3-13, 16-18, 20-23, 25 and 49 - 50 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Liu et al., U.S. Patent No. 6,080,657 ("Liu") in view of Lu et al., U.S. Patent No. 6,365,517 ("Lu"). Applicants respectfully traverse the rejection of claims 1-13, 16-18, and 20-25.

a. *Liu* in view of *Lu* fails to disclose a dielectric layer deposited on a diffusion layer

Liu discloses a "titanium underlayer [that] causes the overlying AlCu layer to be formed in the desired (111) orientation. The presence of the titanium nitride layer underlying the AlCu layer prevents the reaction of the AlCu with the underlying titanium film." See *Liu* column 4, lines 16-20. *Lu* discloses "TiN based films...used to form ...the diffusion barrier/glue layer underlying a conductive gate structure." See *Lu* column 2, lines 52-54. *Lu* further discloses the "diffusion barrier is needed

to prevent a reaction between the tungsten and the poly" in the conductive gate structure. See *Lu* column 5, lines 15-16.

Applicants respectfully submit that *Liu* in view of *Lu* does not disclose depositing a layer of doped dielectric material on a metal nitride or metal oxynitride layer as described in claims 1 and 3 as amended, 22 and 25, but rather discloses depositing metal nitride in a gate stack to "prevent the reaction of the AlCu with the underlying titanium film" or "to prevent a reaction between the tungsten and poly." Thus, the structure of the layers in *Liu* are different from those recited in Applicants amended claims, and disclosure of **different structures** by *Liu* cannot render obvious structures made by methods recited in the instant claims.

Liu further describes "an anti-reflective coating layer 32, such as titanium nitride...deposited over the aluminum layer 30. The aluminum stack is patterned as desired to form metal lines 36. Processing continues..to form the intermetal dielectric layer." See *Liu* columns 3-4, lines 66-67, 1-4. Notwithstanding the Examiner's description in referring to *Kwon* of "a layer 350 which can be of Ti or TiN coating having the inherent diffusion barrier characteristic," the subsequent processing ("the aluminum stack is patterned as desired to form metal lines... Processing continues as is conventional") leaves the sidewalls of the aluminum stack exposed prior to SOG deposition, therefore the "anti-reflective coating layer 32" in *Liu* fails to have "the inherent diffusion barrier characteristic" because the structure is different from that of the Applicants' invention. Therefore, methods for making a different structure cannot be obvious over *Lu* and *Liu*, either alone or in combination with each other.

Since *Liu* in view of *Lu* fails to teach or suggest depositing a layer of dielectric material on a diffusion barrier, *Liu* in view of *Lu* cannot render the rejected claims obvious under 35 U.S.C. §103(a). Dependent claims 3-13, 16-18, and 20-23 depend from independent claims 1 and 22 and are therefore patentable for at least the reasons given for the patentability of claims 1 and 22. Accordingly, Applicants respectfully request that the rejection of claims 1, 3-13, 16-18, 20-23, and 25 under 35 U.S.C. §103(a) be withdrawn. For similar reasons, Applicants submit that claims 49 and 50 are not rendered obvious by *Liu* in combination with *Lu*, and request the rejections be withdrawn.

3. Rejections Over *Liu* in view of *Lu*, and further in view of Inoue

Claims 14 and 15 stand rejected under 35 U.S.C. §103(a) as being unpatentable over *Liu* in view of *Lu*, and further in view of Inoue, U.S. Patent No. 4,976,839 ("Inoue"). Applicants respectfully traverse the rejection of claims 14 and 15.

The Examiner describes *Inoue* as disclosing "the use of Argon in the reactant gases forming TiN." In view of the remarks above, Applicants respectfully submit that claim 1 discloses a different structure from the structure disclosed in *Liu* in view of *Lu*. *Inoue* does not disclose the structure made by methods disclosed in claim 1, therefore claim 1 is patentable over *Liu* in view of *Lu* and further in view of *Inoue*. Dependent claims 14 and 15 ultimately depend from claim 1 and are therefore patentable for at least the reasons given for patentability of claim 1. Accordingly, Applicants request that the rejections of claims 14 and 15 under 35 U.S.C. §103(a) be withdrawn.

4. Rejections Over Kwon in view of Applicants' admitted prior art

Claims 29 and 30 stand rejected under 35 U.S.C. §103(a) as being unpatentable over *Kwon* in view of Applicants' admitted prior art.

The Examiner describes the Applicants' admitted prior art as disclosing "that TiN barrier layer is formed using electromagnetic radiation or nitrogen ion implantation." In view of the remarks above in Section I 2, Applicants respectfully submit that *Kwon* fails to disclose a diffusion barrier being comprised of a layer of metal nitride. Applicants' admitted prior art fails to disclose a diffusion barrier being comprised of a layer of metal nitride; therefore, claim 1 is patentable over *Kwon* in view of Applicants' admitted prior art. Dependent claims 29 and 30 depend from claim 1 and are therefore patentable for at least the reasons given for patentability of claim 1. Accordingly, Applicants request that the rejections of claims 29 and 30 under 35 U.S.C. §103(a) be withdrawn.

5. Rejections Over Akram in View of Wu

Claims 49 and 50 stand rejected under 35 U.S.C. §103(a) as being obvious over Akram in view of Wu et al., U.S. Patent No. 6,013,581 ("Wu"). Applicants respectfully traverse the rejections. As indicated herein above, Applicants submit that Akram fails to teach or suggest structural features of devices made according to methods of the instant claim. Further, Applicants submit that *Wu* fails to teach or suggest structural elements that are missing from Akram.

The Examiner describes *Wu* as disclosing "depositing on a metal layer 202, a diffusion barrier 204, and then depositing a layer of doped dielectric material 206 on said diffusion barrier. Silicon nitride 204 is an etch stop layer having the inherent diffusion barrier characteristic." See

Detailed Action page 2, paragraph 4. Applicants respectfully submit that *Wu* does not disclose "a diffusion barrier being comprised of a layer of metal nitride" as described in claim 1.

Wu discloses an "etching stop 204 [that] includes silicon nitride formed by such as a chemical vapor deposition process..." See *Wu* column 3, lines 5-6. *Wu* fails to disclose an etching stop 204 "being comprised of a layer of metal nitride." Applicants respectfully submit that because *Wu* fails to teach or suggest a diffusion barrier being comprised of a layer of metal nitride, *Wu* cannot render the instant claims obvious, even in light of Akram. Accordingly, Applicants request that the rejection of claim 1 under 35 U.S.C. §102(b) be withdrawn.

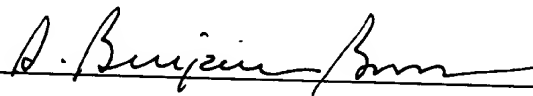
III. Conclusion

In view of the above Amendments and Remarks, Applicants respectfully request that the rejections of Claims 1, 3-23, 25, 29-30 and 48-50 be reconsidered, and that the Examiner provide a Notice of Allowance.

The Commissioner is authorized to charge any underpayment or credit any overpayment to Deposit Account No. 06-1325 for any matter in connection with this response, including any fee for extension of time, which may be required.

Respectfully submitted,

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